Soil Interactions and Collagen Preservation in Leather Artefacts from Vindolanda, Northumberland

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Introduction

Vindolanda is a Roman fort site in Northern England, just south of Hadrian's Wall. Vindolanda is known for exceptional leather preservation, attributed to a variety of agents such as high tannin concentration in the soil, anaerobic conditions and atypical soil chemistry[1]. This poster presents the first results from a laboratory-controlled burial experiment, investigating the relationship between the burial conditions at Vindolanda and leather collagen preservation, aiming to aid site-management and conservation processes.

Methodology

Results from three excavation intervals at 2, 4 and 6 months are presented in this poster, focusing on microscope images and Fourier Transform Infrared Spectroscopy (FTIR). Samples from three different soil types and conditions modelled after Vindolanda are compared: Top soil (TS), waterlogged (WL) and low-oxygen (LO) conditions. FTIR-ATR spectra of freeze-dried oak-tanned leather samples are collected in absorbance mode, using 64 scans at 4 cm^{-1} in triplicate. All spectra are baseline corrected. Collected peak heights represent wavenumbers commonly associated with the collagen backbone structure (fig.1). The Amide 1-3 (A1, A2, A3), 1220 and 1450 peaks are related to the hydrolysis and structure of the triple helix collagen back-bone[2], while the 1750 peak is most likely related to oxidative state of oil in the samples[3]. Internal peak ratios of samples from different soil conditions and burial times are compared using a One-Way ANOVA and Tukey's Honest Significant Difference (HSD) test in IBM SPSS 24.

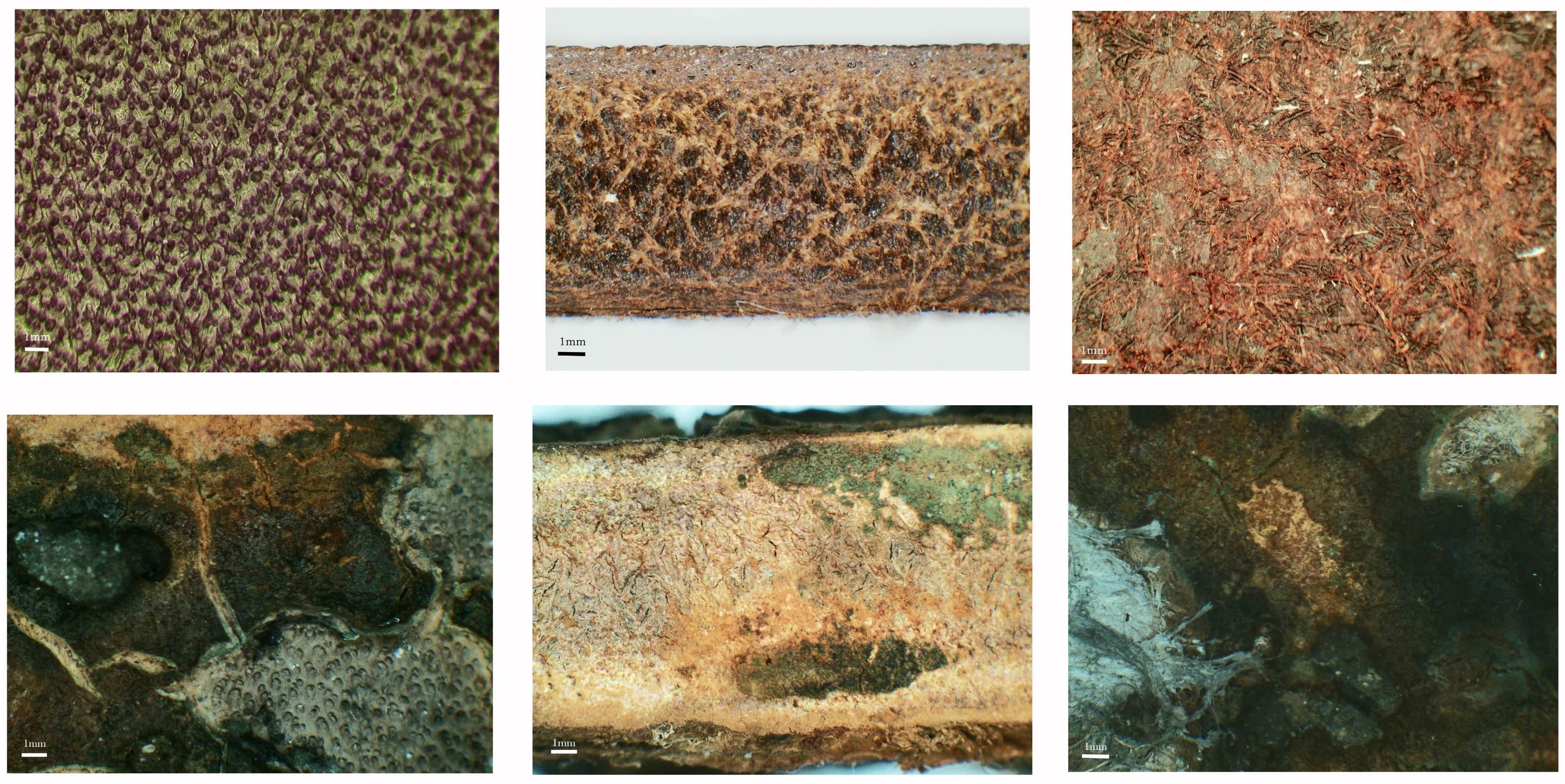
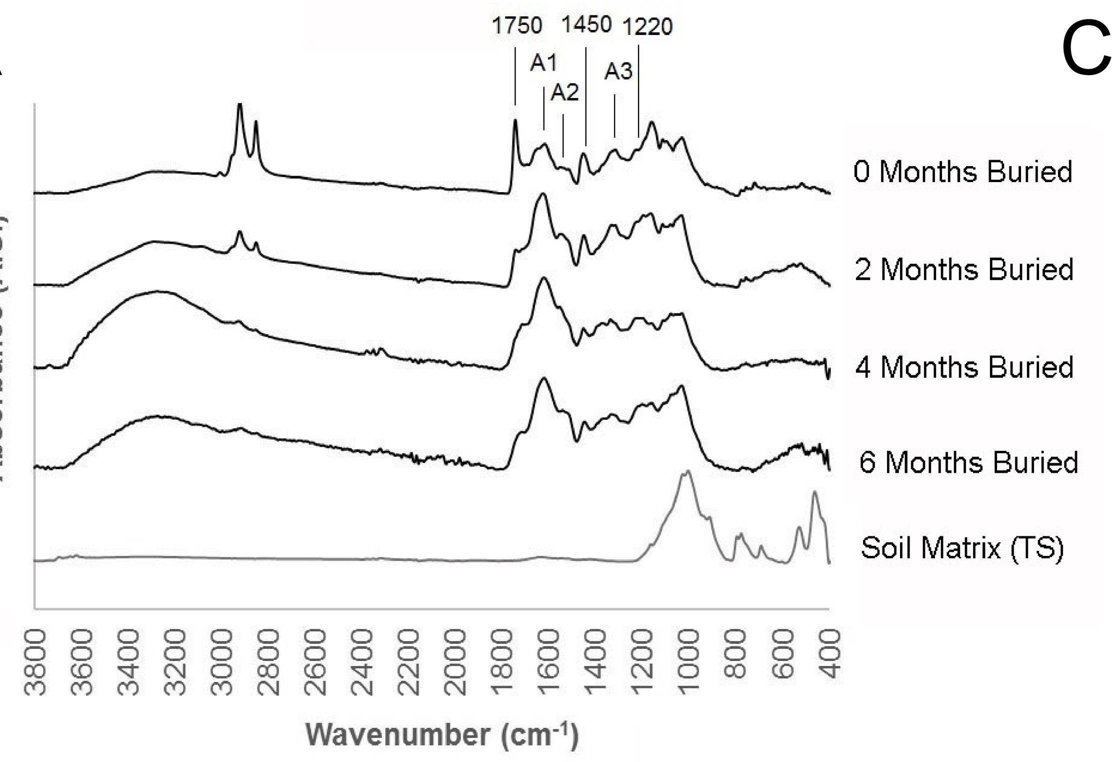


Figure 2: *Microscope images comparing the upper unburied leather to the same sample below after four months of burial in Vindolanda top soil conditions. Images from left to right represent the grain, corium and flesh surfaces Scale in bottom left corner is ~1mm.*

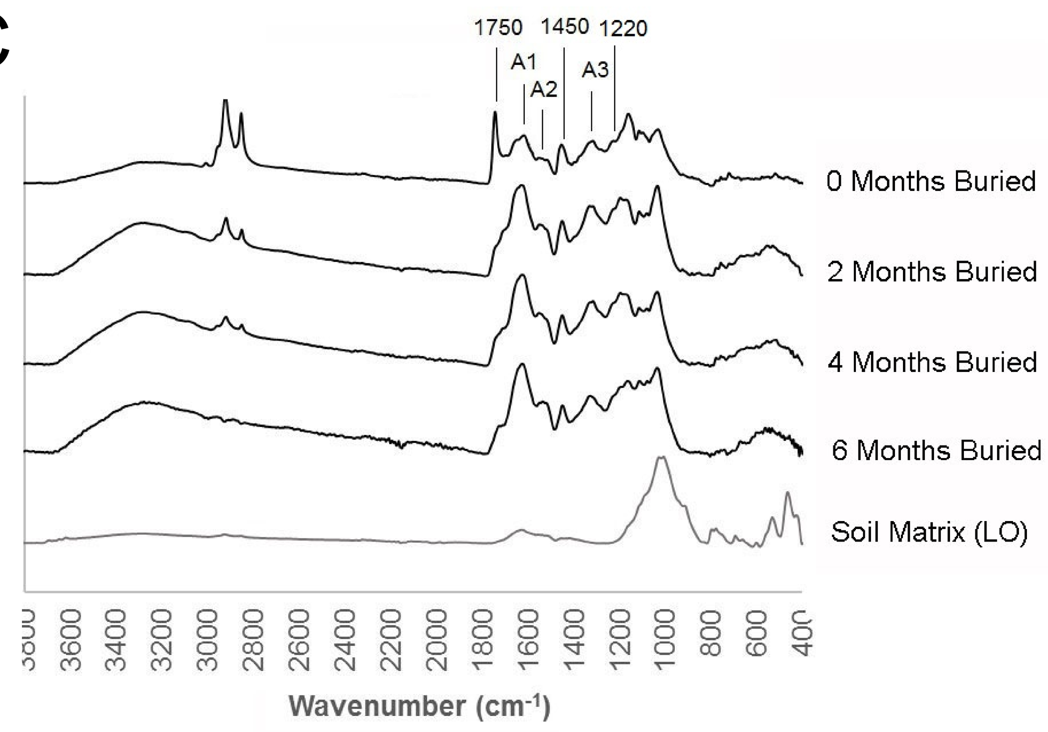
p-value	One-way Anova	Tukey's HSD test		
FTIR Ratio	Between Groups	TS-WL	TS-LO	WL-LO
A3/A1	0.000	0.001	0.004	0.329
A3/A2	0.009	0.062	0.020	0.990
A3/1220	0.000	0.000	0.021	0.009
A3/1450	0.024	0.381	0.022	0.707
1220/A1	0.016	0.115	0.027	0.998
1450/A1	0.000	0.000	0.033	0.046
1450/A2	0.015	0.046	0.057	0.814
1450/1220	0.001	0.001	0.711	0.001
1745/A1	0.000	0.000	0.960	0.000
1745/A2	0.002	0.001	0.999	0.004
1745/A3	0.001	0.007*	0.184*	0.001*
1745/1220	0.000	0.000	0.380	0.000
1745/1450	0.001	0.002*	0.431	0.001

Table 1: p-values (α=0.05) for ratios indicating significant differences between samples buried in the different soil conditions. All sample groups have equal variances, while non-normally distributed sample groups are noted with an asterix. Significant values from Tukey's HSD test are highlighted.

A



C



B

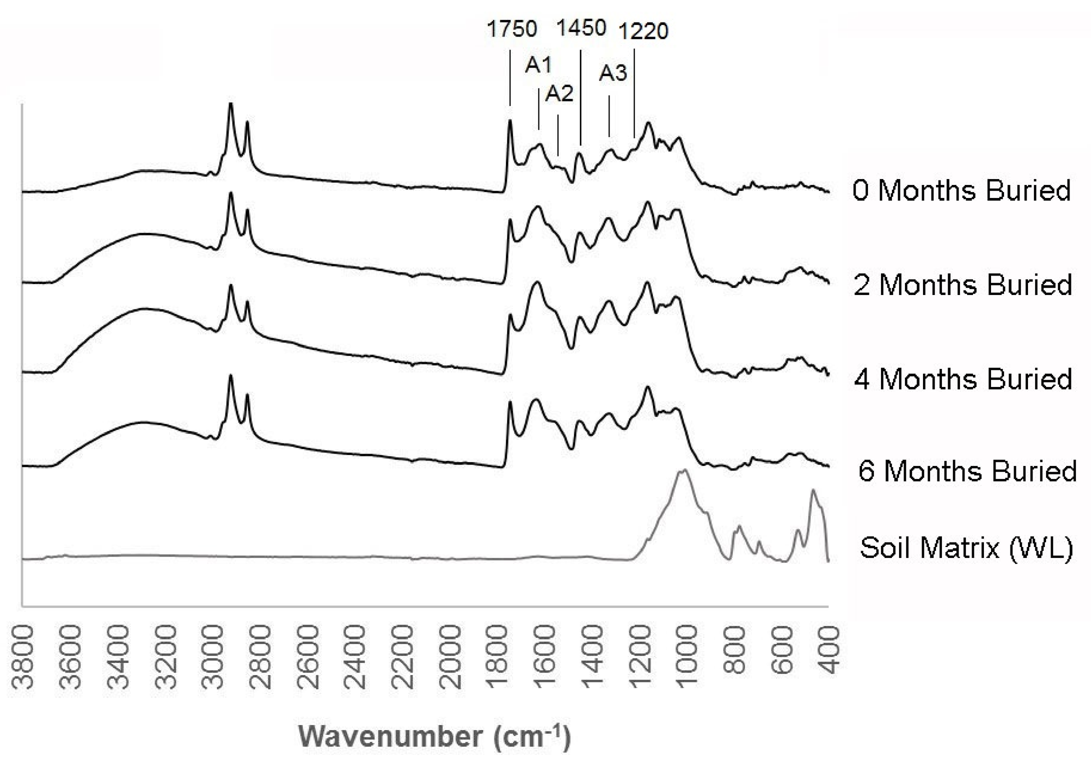


Figure 1 A-C :
Normalised FTIR spectra of oak-tanned leather samples from three different soil conditions. A: top soil (TS) with slow throughput of draining water. B: Waterlogged, silty soil (WL). C: Highly organic soil in low oxygen conditions (LO). In each graph, the top spectrum represents the unburied sample, followed by samples excavated at two month intervals, and finally the soil matrix spectrum.

Results

- Considerable visual changes are apparent after only four months of burial (fig. 2). Such as formation of fungal mycelia, darkening of collage fibers and distortion of the hair-follicle patterns on the grain surface.
- Statistical testing shows that many of the peak ratios bear a strong relationship with the type of burial environment (table 1).
- No statistically significant difference was detected between burial times, perhaps suggesting that the bulk of the degradation has already happened after only two months of burial.
- While the 1750 peak ratios carry the the main distinction between samples from waterlogged and other soil conditions, differences in the collagen structure are more prevalent between samples from top soil and low oxygen conditions.

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ROMAN VINDOLANDA FORT & MUSEUM

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References
1: Birley (2009). *Vindolanda. A Roman Frontier Fort on Hadrian's Wall.*
2: Belbachir *et al.* (2009). *Analytical and Bioanalytical Chemistry*, 829-837.
3: Sommer *et al.* (2017). *Archaeometry*, 287-301.